群馬大学

’13

受験番号	

前期日程

医学部医学科小論文問題

注　意　事　項

1. 試験開始の合図があるまで問題冊子を開いてはいけません。
2. この問題冊子のページ数は10ページです。問題冊子，答案用紙及び下書き用紙に落丁，乱丁，印刷不鮮明などがある場合には申し出てください。
3. 問題を解くに当たっては，「訳注一覧」が問題冊子に挿入されていますので，取り外し開いて使用してください。
4. 解答は指定の答案用紙に記入してください。
   (1) 文字はわかりやすく，横書きで，はっきりと記入してください。
   (2) 解答の字数に制限がある場合には，それを守ってください。
   (3) 訂正，挿入の語句は余白に記入してください。
   (4) ローマ字，数字を使用するときは，ます目にとらわれなくてもかまいません。
5. 試験時間は90分です。
6. 答案用紙は持ち帰ってはいけません。
7. 問題冊子と下書き用紙は持ち帰ってください。

◇M26(707—191)

次の文章を読んで設問Ａ～Ｇに答えなさい。訳注一覧に，＊のついた単語の訳注があります。

The small English mining* town of Bolsover in Derbyshire* enjoyed an unexpected 15 minutes of fame in 1979. While working a coal seam* 500 meters beneath the surface, local miners dislodged* a gigantic fossilized* dragonfly* with a wingspan* of half a meter, rivaling that of a seagull*. Experts from the Natural History Museum in London confirmed that the fossil dated to the Carboniferous* period, about 300 million years ago. The giant was dubbed the Bolsover dragonfly, but although one of the oldest and most beautifully preserved of fossil insects, it was far from unique. Similar fossils from the coal measures* of Commentry of south-east France* had been described by the French palaeontologist* Charles Brongniart as long ago as 1885, and giant dragonflies had since been unearthed* in North America, Russia and Australia. (A) Gigantism* was unusually common in the Carboniferous.

The Bolsover dragonfly belongs to an extinct group of giant predatory* flying insects, thought to have sprung from the same stock as the modern dragonflies (Odonata*) and known as the Protodonata*. Like their modern counterparts, the Protodonata had long narrow bodies, huge eyes, strong jaws and spiny* legs for grasping prey. Pride of place went to the largest insect that ever lived, the colossal* Meganeura*, which had a wingspan of up to 75 centimeters and a diameter across the upper body — the thorax* — of nearly 3 centimeters. For comparison, the largest modern dragonfly has a wingspan of about 10 centimeters and thoracic* diameter of about 1 centimeter. The prototype giant dragonfly differed mostly from its living relatives in the structure of its wings, which were primitive in the number and pattern of veins. The giant size and primitive wing structure led the French scientists (B) Harle and Harle to propose in 1911 that Meganeura could never have managed to fly in our thin modern atmosphere. This startling claim echoed down the corridors of twentieth-century science, to be repeatedly and vigorously rejected by the palaeobiological* establishment. In 1966, the Dutch geologist* M.G. Rutten could write, in a charmingly antiquated* style that has passed forever from the scientific journals:

> Insects reached sizes of well over a meter during the Upper Carboniferous. In view of their primitive means of breathing, by way of trachea* through the external skeleton, it is felt that these could only survive in an atmosphere with a higher O_2 level. As a geologist, the author is quite satisfied with this line of evidence, but other geologists are not. And there is no way of convincing one's opponent.

The idea that giant insects may have required hyperdense*, oxygen-rich air to fly was never quite discredited, and stubbornly refused to go away. We shall see that empirical* measurements may yet succeed where theory has failed. Other factors imply that oxygen levels fluctuated* during the modern era of plants and animals — the Phanerozoic*. Unequivocal* geological evidence shows that the deep oceans contained little dissolved oxygen for at least a short spell, corresponding to the mass extinction at the end of the Permian* period (250 million years ago); and for this to have happened we can only presume that atmospheric oxygen levels fell, at least slightly. Conversely, if we are to believe the principle of mass balance, the vast amount of coal — which is essentially organic matter — buried in the Carboniferous and early Permian period must surely have forced the oxygen levels to rise.

The chief difficulty in calculating changes in the air is to identify which factors control the composition of the atmosphere over geological time, and which are relatively trivial. Take fire as an example. Because fires consume oxygen they are assumed to limit the accumulation of oxygen in the atmosphere. In the absence of human meddling*, fires are typically ignited* by lightning strikes. Under present condition, most lightning strikes do not start fires because forest vegetation* is damp*, especially when electrical storms are accompanied by torrential* rain. But if wet organic matter burns freely in air containing more than 25 per cent oxygen, given an atmosphere with such levels, lightning could trigger conflagrations* even in rain forests. The higher the oxygen level, the greater chance of fire; and as the fires rage they use up excess oxygen. If oxygen levels rise too high, fire would restore the balance.

This simple scenario tends to be accepted uncritically*, but is in fact quite misguided*. Only if the forests are vaporized* will the balance be maintained (just as we vaporize food when we burn it for energy during respiration, giving off carbon dioxide gas and water vapor* in our breath). Anyone who has seen the gutted remains* of a forest after a fire knows that a large amount of charcoal* is formed. Charcoal is virtually indestructible* by living organisms, including bacteria. No form of organic carbon is more like to be buried intact.

We have already seen that oxygen can accumulate in the air only if there is an imbalance between the amount of oxygen produced by photosynthesis* and the amount consumed by respiration*, rocks and volcanic gases. Permanent burial of organic matter is the most important way of disrupting this balance, because it prevents the consumption of oxygen by respiration. Organic remains that are buried are not oxidized* to carbon dioxide, so the oxygen is left over in the air. As charcoal is more likely to be buried intact than normal decaying plant matter, the net result of a forest fire is to increase carbon burial, and thus to raise atmospheric oxygen. This in turn makes fire more likely and pushes up oxygen levels until finally life on land is destroyed. Only then, when all organic production and photosynthesis on land has ceased, can oxygen levels dwindle* slowly, as the gas is removed by reaction with eroded minerals and volcanic gases.

As cited the Dutch geologist M.G. Rutten above, he argued that the primitive means by which insects breathe might limit their size and flight performance. Insects take in air by way of fine tubes or trachea that open directly to the air through pores* in the external skeleton and the branch to penetrate every cell in the insect's body. The idea is that the size of flying insects is restricted by the need for oxygen to diffuse* through the tracheal* system. Any increase in insect size means that oxygen must diffuse over greater distances through the tracheal system, and so makes flight less efficient. The effective upper limit to passive diffusion* down a blind-ending tube (at modern atmospheric levels of oxygen) is about 5 millimeters. According to Robert Dudley, a physiologist* at the University of Texas, an increase in the oxygen content of the air to 35 per cent would increase the rate of oxygen diffusion by approximately 67 per cent, enabling it to diffuse over longer distance. In other words, air that contains more oxygen allows the minimum amount needed for respiration to reach further into the insect's trachea. This would improve the oxygenation* of flight muscles, allowing thicker constructions and permitting insects to grow larger. While other selective pressures, such as predation*, probably drive the actual tendency to get bigger, higher oxygen levels raise the physical barrier to greater size.

So far so good, but there is one problem with this line of reasoning: the tracheal system may be primitive, but it is far from inefficient — with it, flying insects achieve the highest metabolic* rates in the whole of the animal kingdom. Almost without exception, insect flight is totally aerobic*, which means that their energy production is dependent entirely on oxygen. In spite of our $\boxed{\text{C}}$, we are less efficient.

The reason the tracheal system is so efficient is that oxygen remains in the gas phase, where it can diffuse rapidly, and need not pass into solution until the last possible moment, as it enters the flight muscle cells themselves. As a result, the ability of the tracheal system to deliver oxygen typically exceeds the capacity of the tissues to consume it. The only real inefficiency is the blind endings of the trachea, which branch into fine tubules* in much the same way as the blind bronchioles* in our own lungs. Just as we suffocate* if we cannot physically draw breath, so too insects are limited by the diffusion of gases in the blind alleys* of the tracheal system. Most insects get around this difficulty, as we do ourselves, by actively ventilating* their trachea.

In principle, a rise in oxygen levels should enable dragonflies to beat their wings less actively to achieve the same flight performance or, for a constant rate of beating, the body size might be increased. In a detailed study published in the Journal of Experimental Biology in 1998, Hon Harrison of Arizona State University and John Lighton of the University of Utah put these ideas to the test, and finally produced solid evidence that dragonfly flight metabolism* is sensitive to oxygen. They measured carbon dioxide production, oxygen consumption and the thoracic temperature of free-flying dragonflies kept in sealed respiratory* chambers. Raising the oxygen content from 21 to 30 or even 50 per cent increased the metabolic rate. This means that, in today's atmosphere, dragonfly flight is limited by oxygen insufficiency*. If dragonflies can fly better in high-oxygen air, then presumably larger dragonflies, which could not generate enough lift to become airborne* at all in today's thin air, would have been able to fly in (D) the postulated* oxygen-rich mix of the Carboniferous. It seems that the Bolsover dragonfly really was only able to fly, and so hunt its prey and survive, in an oxygen-rich atmosphere.

Dragonflies were not only giants of the Carboniferous — many other creatures attained sizes never matched again. Some mayflies* had wingspans of nearly half a meter, millipedes* stretched for over a meter, and the Megarachne*, a spider-like arachnid* with a leg-span of nearly half a meter, would have chilled the marrow* of Indiana Jones. Even more terrifyingly, scorpions* reached lengths of a meter, dwarfing their modern cousins, the largest of which barely manages a fifth of that length. Among the terrestrial* vertebrates*, amphibians* grew from newt*-like proportions to reach body lengths of 5 meters. They left some of the oldest footprints in England, at Howick in Northumberland* — 18 centimeters long and 14 centimeters across. In the plant world, ferns* turned into trees, while the giant lycopods* reached heights of nearly 50 meters. Their only survivors today are the diminutive* herbaceous* club-mosses*, such as the ground pine, which rarely grow higher than 30 centimeters.

Tucked away* in the 'Scientific Correspondence' section of Nature in May 1999 was a short paper on the size of crustaceans*— the class that includes shrimps, crabs and lobsters — in polar regions. This paper solved a long-standing riddle rather neatly: the relationship between gigantism and oxygen availability. The authors, Gauthier Chapelle of the Royal Institute of Natural Sciences in Belgium, and Lloyd Peck of the British Antarctic Survey, examined length data for nearly 2000 species of crustaceans from polar to tropical latitudes and from marine to freshwater* environments. They focused on a single group, known as amphipods*, which are cold-blooded, shrimp-like creatures, ranging in length from a couple of millimeters to about 9 centimeters.

The thousands of marine species of amphipod are cornerstone* of polar food chains, being the staple diet* of juvenile cod*, which are in turn preyed on by seals*, and the seals by polar bears. In some bottom sediments*, amphipods are found at an extraordinary density of 40 000 per square meter. These tiny creatures offer even more of square meal* in polar waters: the largest Antarctic* species are some five times larger than their tropical cousins — true giants by amphipod standards. In this respect, amphipods are not alone. For the past hundred years or so, scientists have catalogued numerous giant species in polar seas. Although polar gigantism is usually ascribed to* the low temperatures and the reduced metabolic rates of cold-blooded animals, the relationship is not straightforward. Surprisingly, polar gigantism had never been satisfactorily explained. The trouble is that the inverse* correlation* between size and temperature is curved rather than linear*, and has a number of puzzling* exceptions (Figure 1 a). In particular, (E—1) many species achieve far greater sizes in freshwater environments than they ought to on the basis of temperature alone. Freshwater amphipods from Lake Baikal in Russia, for example, are about twice as large as those in the sea at the same temperature.

Then Chapelle and Peck had a clever idea and applied it to their amphipod data. What if the true correlation was not with water temperature at all, but with the dissolved oxygen concentration? (F) Oxygen dissolves better in colder water and is nearly twice as soluble in polar seas than in tropical waters. $\boxed{\text{E—2}}$. When Chapelle and Peck re-plotted their length data against the oxygen saturation* of the water, they got a nearly perfect fit (Figure 1 b). While it is true that a correlation says nothing about mechanism, it seems likely that inadequate oxygen availability limits size in many species, or conversely, that high oxygen raises the barrier to gigantism.

訳注一覧

この「訳注一覧」は問題を解くに当たって，取り外して使用してください。

mining：鉱山業の
coal seam：石炭層
fossilized：化石化した
wingspan：翼長
the Carboniferous：石炭紀
Commentry of south-east France：地名
unearth：掘り出す
predatory：捕食性の
Protodonata：オオトンボ目
colossal：巨大な
thorax：胸部
palaeobiological：古生物学的
antiquated：古めかしい
hyperdense：高密度の
fluctuated：変動する
unequivocal：疑いようのない
meddling：よけいな干渉
vegetation：植物，草木
torrential：激しい
uncritically：いい加減に
vaporize：気化させる
gutted remains：みじめな遺残物
indestructible：分解できない
respiration：呼吸
dwindle：徐々に減少する
diffuse：拡散させる
diffusion：拡散

Bolsover in Derbyshire 地名
dislodge：掘り出す
dragonfly：トンボ
seagull：カモメ
coal measures：石炭層
palaeontologist：古生物学者
gigantism：巨大症
Odonata： トンボ目
spiny：とげのある
Meganeura：メガネウラ（ムカシトンボ）
thoracic：胸部の
geologist：地質学者
trachea：気管
empirical：経験上の
the Phanerozoic：顕正代
the Permian：ペルム紀
ignite：発火させる
damp：湿っぽい
conflagration：大火
misguided：見当違いの
vapor：気化体，蒸気
charcoal：木炭
photosynthesis：光合成
oxidize：酸化させる
pore：小孔
tracheal：気管の
physiologist：生理学者

oxygenation：酸素化
metabolic：代謝の
tubule：小管
suffocate：窒息する
ventilate：換気する
respiratory：呼吸の
airborne：空中に上がる
mayfly：トビゲラ，カゲロウ
Megarachne：メガラクネ
marrow：心髄
terrestrial：地球上の
amphibian：両生類
Howick in Northumberland：地名
lycopod：コケの一種
herbaceous：草性の
tuck away：しまい込む
freshwater：淡水の
cornerstone：礎
cod：タラ
sediment：沈殿物
Antarctic：南極の
inverse：逆の
linear：線形の
saturation：飽和
predation：捕食
aerobic：好気性の
bronchiole：細気管支
blind alley：袋小路
metabolism：代謝
insufficiency：不足
postulated：仮定される
millipede：ヤスデ
arachnid：クモ類動物
scorpion：サソリ
vertebrate：脊椎動物
newt：イモリ
fern：シダ
diminutive：小さい
club-moss：コケ，ヒカゲノカズラ
crustacean：甲殻類
amphipod：ヨコエビ
staple diet：主食
seal：アザラシ
square meal：十分な食事
be ascribed to ～：～による
correlation：相関関係
puzzling：よく分からない

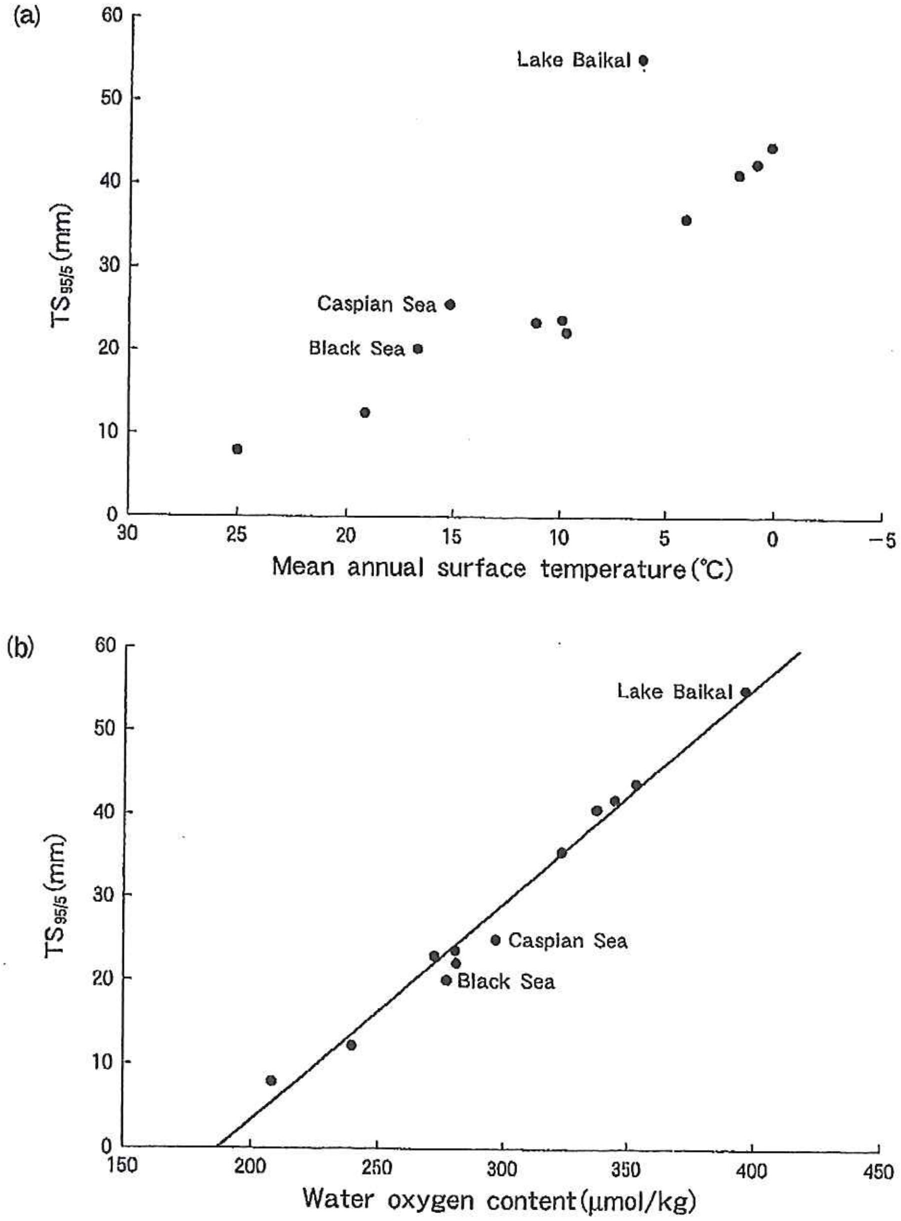

Figure 1: Correlation between body length of amphipods in millimeters (given as an index of average length, TS 95/5) and (a) temperature and (b) oxygen concentration.

(Nick Lane 著, "Oxygen" Oxford University press 社より, 一部改変)

設　問

A．下線(A)の理由として筆者はどのように考えているか。答案用紙$\boxed{1}$のＡ欄に日本語 20 字以内（句読点も含む）で記入しなさい。

B．下線(B)に関して，彼らは何故そのように考えたのか。答案用紙$\boxed{1}$のＢ欄に日本語 100 字以内（句読点も含む）で記入しなさい。

C．空欄$\boxed{\quad\text{C}\quad}$には，ヒトの酸素供給・運搬にかかわるシステムが列記されている。答案用紙$\boxed{1}$のＣ—１欄に日本語で４つ記入しなさい。

また，このシステムが昆虫のものよりも，効率が悪い理由を答案用紙$\boxed{1}$のＣ—２欄に日本語 90 字以内（句読点も含む）で記入しなさい。

D．下線(D)に関して，このように想定されている原因は何か。時代背景も考慮し，答案用紙$\boxed{2}$のＤ欄に日本語 120 字以内（句読点も含む）で記入しなさい。

E．下線（Ｅ—１）の理由が$\boxed{\text{E—2}}$に述べられている。$\boxed{\text{E—2}}$で述べられている下線（Ｅ—１）の理由を，~~図１~~Figure 1を参考にして推測し，何がどの程度違うのかも含めて，答案用紙$\boxed{2}$のＥ—１欄に日本語 60 字以内（句読点も含む）で記入しなさい。

また，$\boxed{\text{E—2}}$のようになる物理化学的な理由について，どのようなことが考えられるか，考えたことを答案用紙$\boxed{2}$のＥ—２欄に日本語 50 字以内（句読点も含む）で記入しなさい。

F．下線(F)に関して，0 ℃の海水と 25 ℃の海水１Ｌに溶けている酸素の体積はそれぞれどれほどか。~~図１~~Figure 1を参考に，気圧 1.0×10^3 hPa，海水密度を 1.0 g/ml，気体定数 8.3×10^3 Pa·L/(K·mol)，酸素は理想気体としてふるまうと仮定し，答案用紙$\boxed{3}$のＦ—１欄に計算過程と答えを書きなさい。

また，温度により溶解酸素量が変化する物理化学的な理由としてどのようなことが考えられるか，考えたことを，答案用紙$\boxed{3}$のＦ—２欄に日本語 60 字以内（句読点も含む）で記入しなさい。

G．PeckとChapelleはその後ペルーとボリビアの国境にあるチチカカ湖(水温12℃，標高3809 m)のamphipodの体長を測定した。Figure 1 (a)を参考に体長の推定値を答案用紙$\boxed{3}$のG―1欄に記入しなさい。またチチカカ湖において推定値の設定に用いた以外の，体長に影響を与える要素があるとすれば，それは推定値にどのように作用すると考えられるか，考えたことを答案用紙$\boxed{3}$のG―2欄に日本語で記入しなさい。但し，体長に関して設定した推定値以外の具体的数値は記す必要はない。